
Prevalence of Health Problems Caused by Water Pollution Around Industrial Zones in the City of Douala, Cameroon

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Abstract

Introduction:

The Intensification of Industrial Activities in the City of Douala is Accompanied by Strong Urban Growth. This Situation Contributes to a Deterioration in Water Quality, Particularly Through the Discharge of Pollutants, Leading to a Cause for Concern About Their Effects on People's Health. The Aim of This Study is Therefore to Assess the Prevalence of Health Problems Among Residents Living Around Industrial Zones.

Methodology:

A Cross-sectional and Analytical Study Was Conducted With Residents of the Main Industrial Areas of Douala From January 2024 to July 2024 (7 Months). Every Inhabitant of This Zone Aged 21 Was Included in This Study. The Data Were Collected Using a Structured Questionnaire That Covered Socio-demographic Information, Water Use Habits and Medical History. Analysis Was Carried Out Using Excel 2015 and Spss 20 Software to Explore Associations Between the Variables Studied.

Results:

The Study Included 1,023 Participants (That is, 489 Women and 534 Men), With a Predominance (49.9%) of Young Adults Ranging From 20-30 Years. Around 80% of the Participants Used Alternative Water Sources, Often of Uncertain Quality. The Most Frequently Reported Health Problems Were Digestive Disorders (92.1%; $P < 0.001$), Joint Pains (86.1%; $P < 0.001$), Skin Ailments (77.6%; $P < 0.001$) and Water-borne Diseases (72.6%; $P < 0.001$), With Higher Rates in Households Located Near Industries. The Results Show a Correlation Between the Use of Potentially Polluted Water and the Appearance of Certain Pathologies. The Proximity of Homes to Industrial Sites, Combined With Dependence on Alternative Water Sources, Could Contribute to Prolonged Exposure to Contaminants. These Observations Are Consistent With Other Studies Conducted in Similar Contexts.

Conclusion:

This Study Shows a Link Between 'industrial Water Pollution' and the Health of People Living Near Industrial Zones in Douala.

Keywords: Pollution, Industrial Zones, Water, Health Problems, Douala.

Introduction

Global industrialization has expanded significantly in recent decades, leading to major economic transformations and rapid urbanization. However, this industrial growth is often accompanied by adverse effects on the environment and public health (**Onounga et al. 2023**). Industrial activities are a major source of air, water, and soil pollution, exposing the surrounding populations to various harmful pollutants (**Ngugi et al. 2022**). In Africa, where the challenges of managing industrial zones are still numerous, industrial emissions are responsible for the ongoing degradation of water resources, endangering the health of local communities and of the surrounding biodiversity (**Samantha, 2021**).

Today, only 50% of the population of Douala is connected to the public drinking water supply network, managed by the Cameroon Water Utilities Corporation (Camwater). As a result, a majority of households rely on alternative sources, such as boreholes, wells and natural water points to cover their water needs (**Mbida Mbida et al. 2017, Nlend et al. 2018**).

These communities, which are particularly vulnerable to harmful environmental exposure, are at high risk of developing health problems. Studies such as **Ngo Boum et al. (2023)** have revealed the presence of heavy metals, particularly lead and mercury, in the waterways that flow through the industrial zones of Douala. However, specific data concerning the impact of industrial pollutants on the health of the population of Douala remain limited. This work aims to explore the influence of residential proximity to industrial areas on the prevalence of health problems.

Materials and Method:

We conducted an analytical cross-sectional study in the industrial areas of Douala, Cameroon. The aim of this research was to study the relationship between residential proximity to industrial zones and the frequency of health problems. Through a quantitative analysis of data, we identified the associated risk factors and assessed their impact on the health of the local population. A consecutive non-probability sampling was used. The minimum sample size was calculated using Lorentz's formula: $N = 384$ participants for each industrial zone. In order, to cover all industrial zones, the size of the initial sample was increased to a total of 1023 participants.

Our sample population consisted of households in which each participant received an information leaflet detailing the aims of the study, the advantages, and disadvantages of participation, as well as the ethical considerations associated with the research. Only participants who had given their consent were selected and invited to answer a multiple-choice questionnaire developed on the basis of the study by **Blaise et al. (2023)**.

The information collected from the questionnaire was supplemented by visual observations of the areas studied. The aim of these inspections was to identify possible direct industrial discharges into watercourses or seepage into groundwater likely to affect the quality of surface and water tables. The study was carried out with the prior agreement of the heads of the institutions concerned. It has scrupulously respected ethical and scientific principles, namely: clearly defined objectives, an exclusive use of data collected for research purposes, and guaranteed anonymity of participants throughout data processing.

Access to the information collected was strictly limited to members of the research team. The data was treated with the utmost confidentiality, in compliance with current regulations and ethical standards in the field of research.

The data collected was carefully organized and verified to ensure its quality and consistency. A descriptive analysis was carried out to summarize the socio-demographic characteristics of the participants and the variables studied, using frequencies, proportions, and averages. Subsequently, a bivariate analysis was then carried out to explore the relationships between the independent variables, such as residence in industrial zones, and the dependent variable like the presence of health problems.

Excel software was used to present the results in the form of tables and graphs, accompanied by a detailed and contextualized interpretation.

Results:

1. Socio-demographic data

1.1 Distribution of the population by sex:

Our sample comprised 1023 participants, 489 women and 534 men, with a M/F sex ratio of: 1,09.

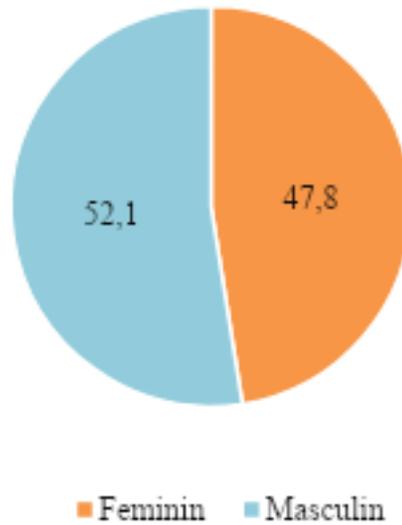


Figure 1: Breakdown of the population by gender

1.2 Breakdown of the population by age group:

The average age of the participants was 37.64 ± 9.35 years, with extremes ranging from 21 to over 50 years. The most represented age group was the 20-30, which made up almost half of the sample (49.9%).

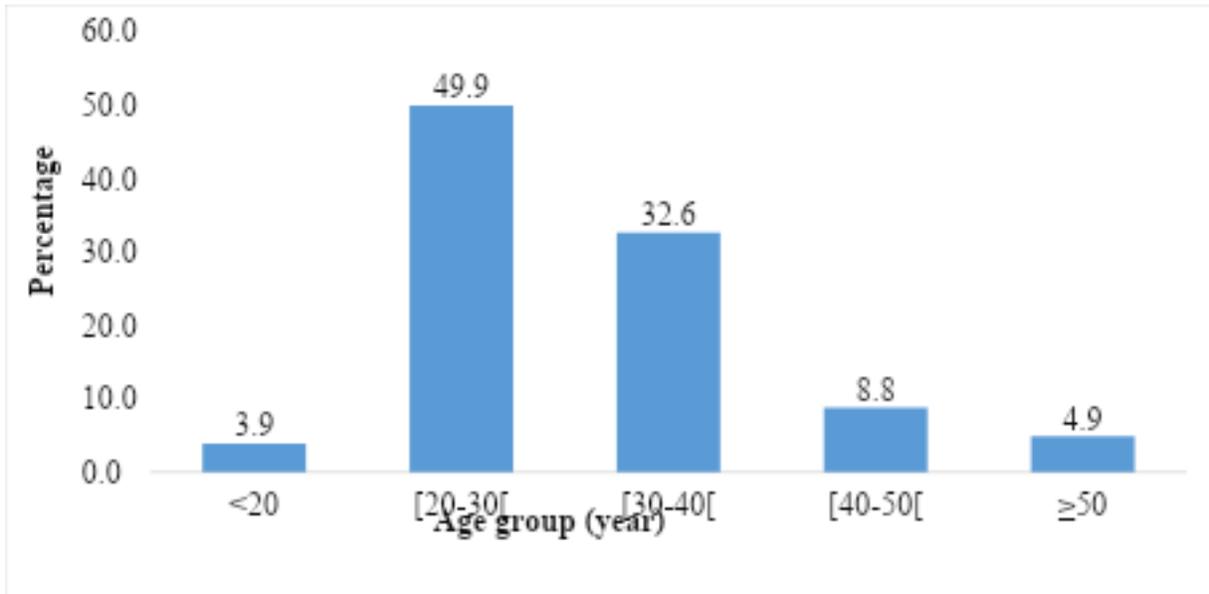


Figure 2: Population distribution by age group

1.3 Population distribution by location

Figure 3 shows that Bonabéri is the most densely populated industrial zone, accounting for 50% of the inhabitants of Douala's industrial zones, or 511 people out of a total of 1.023.

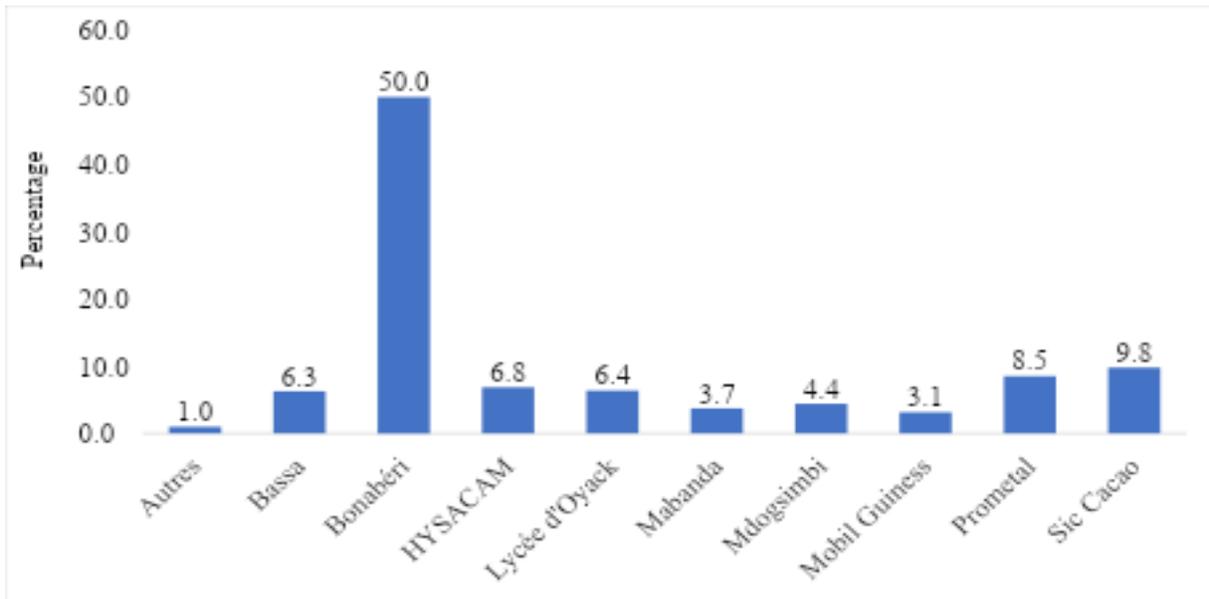


Figure 3: Population distribution by location zone

1.4 Distribution of sources of water supply for the population

Figure 4 shows that only a minority of the population living in Douala's industrial zones, i.e. 20%, use the drinking water supplied by Camwater. Most residents (80%) obtain their water from alternative sources, such as boreholes (45%) and wells (35%), although the quality of the water consumed is not necessarily guaranteed.

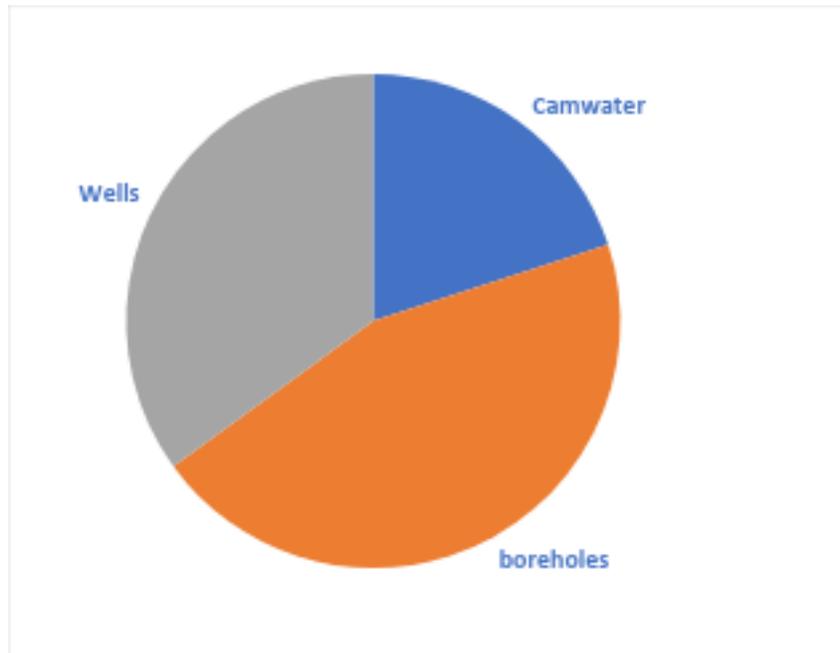


Figure 4: Distribution of sources of water supply for the population

2.1 Reported rates of health problems in Douala's industrial zones

As shown in Figure 5, people living in Douala's various industrial zones report a variety of health problems, represented as follows. Thus, 92.1% of participants reported digestive problems, 86.2% complained of muscular pains, 77.6% had skin problems and 72.6% suffered from diarrhea. On the other hand, cases of cancer and congenital malformations were relatively infrequent.

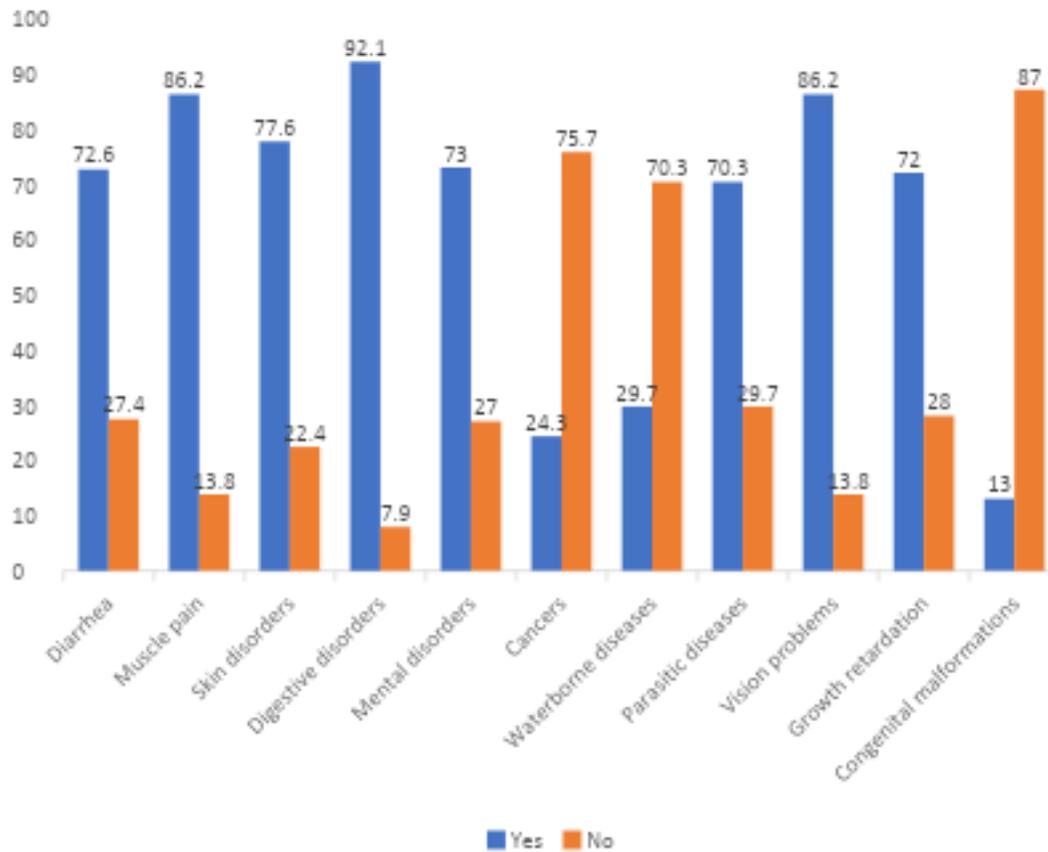


Figure 5: Frequency of declarations of health problems in industrial zones in the Littoral region of Cameroon.

Table 1: Frequency of muscular pain by industrial zone

Muscular pains		Locality									Total
		Sic Cacao	Bonabéri	Hysacam	Lycée d'oyack	Mabanda	Ndotsimbi	Mobile Guinness	Prometal	Others	
Yes	Workforce	54	127	67	101	221	31	58	217	5	881
	Workforce %	68,3%	86,3%	76,1%	90,9%	92,0%	77,5%	84,0%	91,5%	41,6%	86,2%
No	Workforce	25	20	21	10	19	9	11	20	7	142
	Workforce %	31,4%	13,6%	23,8%	9,0%	7,9%	22,5%	15,9%	8,4%	58,3%	13,8%
Total	Total workforce	79	147	88	111	240	40	69	237	12	1023
	Total %	100%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

P-value < 0.001

Table 1 shows that the Prometal area has the highest prevalence of muscular pain, with 91.5% of cases, followed closely by Bonaberi, where 86.3% of residents reported suffering from it. Conversely, the Ndotsimbi area had the lowest prevalence, with only 31 cases reported.

Table 2: Frequency of skin disorders by locality

Skin disorders		Locality									Total
		Sic cacao	Bonabéri	Hysacam	Lycée d'oyack	Mabanda	Ndotsimbi	Mobile Guinness	Prometal	Others	
Yes	Workforce	47	107	178	93	121	51	100	81	15	793
	Workforce %	59,4%	84,2%	89,4%	71,5%	75,6%	73,9%	79,3%	72,9%	68,1%	77,6%
No	Workforce	32	20	21	37	39	18	26	30	7	230
	Workforce %	40,5%	15,7%	10,5%	28,4%	24,3%	26,0%	20,6%	27,0%	31,8%	22,4%
Total	Total workforce	79	127	199	130	160	69	126	111	22	1023
	Total %	100%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

P- value < 0,001

Table 2 shows that residents of the Hysacam zone have the highest frequency of skin disorders, affecting 89.4% of residents, followed by Bonaberi where 84.2% of residents are affected. Conversely, the Sic cacao zone recorded the lowest frequency, with 47 cases.

Discussion:

The aim of this study was to investigate the health problems generated using water around the industrial zones of the city of Douala in Cameroon. It shows that the population in these zones is very young. The study population consisted of 1,023 participants being 489 women and 534 men, representing 91.3% of the population previously mentioned. The average age of the participants was 37.64 ± 9.35 years, with extreme values ranging from 20 to over 50 years.

The most represented age group was the 20-30 years age group, which constituted almost half of the sample (49.9%) population. This predominance can be attributed to several factors, including the search for employment opportunities, particularly abundant in industrial areas which are characterized by a wide range of industrial and commercial activities.

In addition, this young population was more accessible and more willing to take part in a survey on environmental and health risks. Compared with other studies conducted in similar contexts, this age distribution seems consistent with trends observed in industrial areas where the working population is predominantly young **Hegazy et al. (2020)**.

The results of our work showed that Bonaberi is the most represented industrial zone, accounting for 50% of the study population, that is, 511 people out of a total of 1,023 (one thousand, twenty-three).

These observations are in line with the work of **Moghimi et al. (2024)**, who demonstrated that residential areas located near strategic infrastructures, such as ports or industrial complexes, favour rapid urbanization and high population density.

According to our data, only 20% of the population living in the industrial zones of Douala use the drinking water supplied by the sole National water company (CAMWATER), a rate similar to that reported by **Ngo Boum et al. (2023)**.

This low supply of drinking water could encourage the population to resort to alternative sources, such as boreholes and wells, despite the risks of contamination, as pointed out by **Gisèle (2017)**.

These observations are in concordance with the work of **Foster et al. (2020)**, who reports that in many parts of sub-Saharan Africa, a large proportion of rural and peri-urban populations are turning to alternative water sources, such as boreholes and wells, because of an inadequate public supply network.

A study conducted in Cameroon by **Santsa et al. (2022)** found that untreated water used for daily activities can be contaminated with pathogens, thus exposing people's health to significant risks. In addition, the use of this water in agricultural (97.4%) and related activities, such as livestock rearing and gardening (95.9%), could favor the accumulation of pollutants in agricultural and animal products. These practices represent an indirect risk to human health, as highlighted by **Soumbougma et al. (2020)**, who have established a link between irrigation with contaminated water and the accumulation of heavy metals in crops.

Industrial areas, which are often exposed to various types of pollution, are breeding grounds for the development of a wide range of pathologies. This situation raises major concerns about the health risks to which residents are exposed (**Kouamé et al. 2014**).

Water contaminated by industrial discharges fusions with tidal waters, infiltrating the water tables. This phenomenon directly compromises water resources intended for domestic consumption. This contamination encourages the emergence of non-transmitted diseases, increasing the vulnerability of population living in these industrial areas. As a result, people living in these high-risk areas are particularly exposed to certain pathologies, notably water-borne diseases, which have accounted for more than 60% of medical consultations in recent years (**Gisèle, 2017**). The results of our study revealed a high prevalence of muscular pain among people living near the industrial zones of Douala, with significant inequalities between localities. The Prometal area for instance, recorded the highest prevalence (91.5%), followed by Bonabéri (86.3%) and Oyack (90.9%). In contrast, the Ndogsimbi area has the lowest prevalence, with only 31 cases reported. These disparities seem to be linked to the intensity of industrial activities and increased exposure to certain polluting agents, in particular heavy metals such as lead and cadmium, which are known to cause muscular disorders **Adeyemi et al. (2021)**.

Previous studies have shown that chronic exposure to these substances can lead to muscular disorders such as myalgia and muscle weakness (**OMS, 2021; Ismanto et al. 2022**). The most affected areas, such as Prometal and Bonaberi are characterized by a high concentration of industrial activities, which could explain higher prevalence levels. Conversely, areas such as Ndogsimbi, with an average rate of muscular pain (77.5%), could benefit from reduced exposure to pollutants with a low density of industrial activity or a relatively more favorable healthy environment. These results are in line with those of **Schraufnagel et al. (2019)** who found a link between proximity to industrial areas and an increased risk of musculoskeletal diseases.

Our study revealed that the distribution of health disorders varies according to distance from industrial zones. Populations residing less than 5 kilometers from these zones have a higher

incidence of health disarrays. Prolonged exposure to high levels of toxic products from industrial emissions contributes to progressive impairment of organ functions in the long term. This link between proximity to industrial zones and the health problems observed in residents demonstrate the crucial role played by industrial zones in deteriorating the health of local populations. Like muscular pain, skin disorders are common in these areas, where residents are exposed to various pollutants. The results show significant variations in the frequency of skin disorders depending on the areas studied. The Hysacam area (Hygiene and cleanliness in Cameroon) recorded the highest frequency, with 89.4% of cases reported (despite being a hygiene and sanitation company), followed by Bonaberi with 84.2%. In contrast, the Sic Cacao area, which is less industrialized and has a more controlled environment, has a low prevalence of skin disorders. This suggests that low levels of industrial activity result in a low incidence of this type of pathology. The high incidence of skin disorders in the Hysacam and Bonaberi areas may be attributed to the intense waste management activity concentrated there, combined with the absence of strict environmental control policies, as well as working and living conditions that expose residents to irritating substances. Direct contact with waste, particularly through informal recycling activities, exposes people to more of these harmful substances, increasing the risk of developing dermatitis in exposed populations **Coulibaly et al. (2023)**

The prevalence of mental disorders varies between industrial zones, reaching 41.3% in the Oyack high school zone, while no cases were declared in the Sic Cacao zone. This variation could be explained by a combination of environmental and socio-economic factors specific to each zone. This zone, which has the highest rate of reported mental disorders, is heavily exposed to industrial pollutants. Prolonged exposure to certain contaminants, such as heavy metals, is associated with neurological changes and the commencement of psychological disorders, which could contribute to the increase in mental disorders in this area (**Kengni et al. 2012, Etoh et al. 2016**). These factors could explain the high prevalence of mental disorders in this area. The study by **Vardhan et al. (2019)** in India shows that exposure to industrial pollutants has had adverse consequences on mental health, by causing anxiety, depressive and cognitive disorders. The data in this study show that cancer rates vary according to industrial zone, with a particularly high incidence in the Mabanda zone (38.9%). A review by **Silva et al. (2024)** emphasizes that environmental pollution is a major risk factor for certain types of cancer, particularly lung, bladder, and kidney cancer. The high incidence observed in Mabanda could be linked to its proximity to industries that emit carcinogenic substances such as heavy metals. In addition, a study by **Cazolla et al. (2023)** in Italy shows that industrial areas with a high concentration of polluting activities, such as refineries or chemical plants, are associated with a higher incidence of cancer among neighboring populations.

Prolonged exposure to industrial pollutants, which have the capacity to accumulate in agricultural produce (the main source of food for local populations), can lead to developmental disorders in children living in industrial areas **Fantong et al. (2016)**. In the Hysacam area, where the stunting rate is at its highest, the presence of waste management industries and other industrial infrastructure could be a significant source of pollution, likely to affect children's

growth. These pollutants disrupt the absorption of essential nutrients and cause chronic gastrointestinal disorders that can hinder the normal development of children **Zaynab et al. (2022)**. Furthermore, **Tatou R et al. (2017)** reveal that children living near industrial areas had higher rates of stunted growth and malnutrition rates due to the consumption of food contaminated by polluting substances. The Sic Cacao area, which has no cases of stunting, benefits from a healthier environment, with less exposure to industrial pollutants and better access to health and nutrition facilities. According to data from the World Health Organization (WHO), the prevalence of growth retardation among children under 5 in Cameroon was 32%, with higher figures in industrial areas in 2014. Bonaberi, which is the main industrial zone in Douala, is home to a variety of manufacturing, chemical and processing industries whose activities expose residents to various teratogenic agents and could contribute to the high prevalence of congenital malformations. Likewise, studies such as **Yaakov Bentov et al. (2006)** show that populations living near industrial zones are at increased risk of congenital malformations due to exposure to teratogenic agents. Similarly, a study by **Charlotte et al. (2015)** in Cameroon shows that exposure to certain chemicals, including endocrine disruptors, could increase the risk of malformations in newborns. It is also important to consider that workers in the Bonaberi industries may be exposed to toxic substances in the workplace, increasing the risk of birth defects in their offspring. Areas such as Sic cacao and Mobil Guinness, where no cases of congenital malformations have been reported, are either less industrialized, or local industries are more respectful of environmental regulations, which reduces the exposure to the various dangers of pollution. The geographical variations observed in the prevalence of congenital malformations in Douala highlight the need for further research to identify the risk factors specific to each zone. It is also important to conduct detailed epidemiological studies to assess the impact of industrial pollutants on the reproductive health of local populations. However, although most studies support this trend, some work, like **Amar (2017)**, suggest that other socio-economic and environmental factors, such as lifestyle, access to healthcare and dietary habits, may also play a determining role in the incidence of non-communicable diseases.

Limitations:

This work encountered such difficulties as accessing households, establishing relationships of trust with local communities, and obtaining their active participation in the study.

Conclusion

Environmental pollution is a global issue that transcends the local context of Douala. It reflects a wider public health problem faced by many growing industrial cities, particularly in developing countries. The impacts of this pollution are multiple and upsetting, as they affect communities living close to industrial sites. This study, carried out in the industrial zones of Douala, revealed a significant link between residence near industries and the occurrence of health problems, thereby calling for the integration of environmental issues in public health policies.

Ethics:

The study was conducted in accordance with ethical guidelines related to research in Cameroon. It was approved by the Institutional ethics committee for Human Health Research of the University of Douala (N°4106/CEI-UDo/01/2024/T) and the research authorizations from the Governor of the Littoral region (N°100/AR/C/SG/DAAJ) and the Regional Delegate for the Environment, Nature Protection and Sustainable Development (N°001/AR/24/RTL/DREPDED)

Authors Contribution:

ADIOGO Dieudonne, TEMFEMO Abdou, NNANGA NGA Emmanuel, FADIMATOU Ahmadou: Study design and planning, questionnaire Development.

FADIMATOU Ahmadou, NGONO Floride Enstelle, TCHOKONTE HAPPI Karell: Data collection in the field.

TEMFEMO Abdou, Kubra ALTUNTAS: Data Analysis

All authors participated in the writing, review, and validation of the manuscript.

Competing Interests:

The authors declare that they have no competing interests regarding the publication of this article.

References

- Adeyemi AA, Ojekunle ZO. 2021. Concentrations and health risk assessment of industrial heavy metals pollution in groundwater in Ogun state, Nigeria. *Scientific African*. (11).
- Amar E. 2017. Malformations et facteurs environnementaux. *Revue de Médecine Périnatale*. 9(2):73-80.
- Bentov Y, Kordysh E, Hershkovitz R, Belmaker I, Polyakov M, Bilenko N, Sarov B. 2006. Major congenital malformations and residential proximity to a regional industrial park including a national toxic waste site: An ecological study. 5(1):8
- Blaise NYH, Philippes MF, Hubert A. 2023. Etude exploratoire des problèmes de santé dans la commune d'arrondissement de Manoka (Littoral camerounais). *International Journal of Science Academic Research*.04(06) :5791-5803
- Boum-Nkot SN, Nlend B, Komba D, Ndondo GRN, Bello M, Fongoh EJ, Ntamack NMJ, Etame J. 2023. Hydrochemistry and assessment of heavy metals groundwater contamination in an industrialized city of sub-Saharan Africa (Douala, Cameroon). Implication on human health. *HydroResearch*.6:52-64.
- Cazzolla Gatti R, Di Paola A, Monaco A, Velichevskaya A, Amoroso N, Bellotti R. 2023. The spatial association between environmental pollution and long-term cancer mortality in Italy. *Science of The Total Environment*.855:158439.
- Charlotte TN, Aurore ND, Charlotte B, Esther B, Eugene BP. 2015. Prenatal Diagnosis of Congenital Malformations in Douala General Hospital. *Open Journal of Obstetrics and Gynecology*. 5(15) :839-48.

- Coulibaly M, Tuo P, Traore D, Sarambe I. 2023. La santé des populations vivant dans le bassin de la rivière Tiologo dans la ville de Korhogo (nord de la Côte d'Ivoire). *Revue Internationale du Chercheur*.4(4).
- Etoh MA, Dina DJD, Yinyang J, Assokom E, Nguene JP, Adiogo J. 2016. Aluminium Contents in Superficial Water of Great Rivers in the Littoral Region of Cameroun. *International Journal of Current Research and Academic Review*. 4(2): 82- 88
- Fantong WY, Kamtchueng BT, Ketchemen-Tandia B, Kuitcha D, Ndjama J, Fouepe AT, Takem GE, Issa, Wirmvem MJ, Djomou SLB, Ako AA et al. 2016. Variation of hydrogeochemical characteristics of water in surface flows, shallow wells, and boreholes in the coastal city of Douala (Cameroon). *Hydrological Sciences Journal*.61(16) :2916-29.
- Foster S, Eichholz M, Nlend B, Gathu J. 2020. Securing the critical role of groundwater for the resilient water-supply of urban Africa. *Water Policy*.22(1):121-32.
- Gisèle B. 2017. Pollution des eaux et rivières et impact sur les populations riveraines : cas de la rivière Mgoua dans la zone industrielle de Douala-Bassa. (Master en Gestion de l'eau). Université de Dschang, Faculté d'Agronomie et des Sciences Agricoles.73p
- Hegazy D, Abotalib AZ, El-bastaweey M, El-said MA, Melegy A, Garamoon H. 2020. Geo-environmental impacts of hydrogeological setting and anthropogenic activities on water quality in the quaternary aquifer southeast of the Nile Delta, Egypt. *Journal of African Earth Sciences*. 172 : 103947
- Ismanto A, Hadibarata T, Widata S, Indrayanti E, Ismunarti D, Safinatunnajah N, Kusumastuti W, Dwiningsih Y, Alkahtani J. 2023. Groundwater contamination status in Malaysia level of Heavy Metal source, Health impact, and remediation technologies. *Bioprocess and Biosystems Engineering*. 46 (3): 465-482
- Kengni L, Tematio P, Filalirharrassi K, Nguéke JT, Tsafack EI, Mboumi TL, Mounier S. 2012. Pollution des eaux superficielles et des nappes en milieu urbain : cas de la zone industrielle de Douala-Bassa (Cameroun). *International Journal of Biological and Chemical Sciences*. 6(4) :1838-53.
- Kouamé AN, Amani MK, Gnaboa R, Traoré KS, Houenou PV. 2014. Analyse des phénomènes hydrologiques dans un bassin versant urbanisé: cas de la ville de Yamoussoukro (centre de la Côte d'Ivoire). *larhyss Journal*.17.
- Mbida Mbida A, Etang J, Akono Ntonga P, Eboumbou Moukoko C, Awono-Ambene P, Tagne D, Talipouo A, Ekoko W, Binyang J, Tchoffo R, Lehman G, Mimpfoundi R. 2017. Nouvel aperçu sur l'écologie larvaire d'*Anopheles coluzzii* Coetzee et Wilkerson, 2013 dans l'estuaire du Wouri, Littoral-Cameroun. *Bulletin de la Société de Pathologie Exotique*.110(2) :92-101.
- Moghimi Dehkordi M, Pournuroz Nodeh Z, Soleimani Dehkordi K, Salmanvandi H, Rasouli Khorjestan R, Ghaffarzadeh M. 2024. Soil, air, and water pollution from mining and industrial activities: Sources of pollution, environmental impacts, and prevention and control methods. *Results in Engineering*. 23 :102729.

- Ngugi MM, Gitari HI, Muui CW, Gweyi-Onyango JP. 2022. Growth tolerance, concentration, and uptake of heavy metals as ameliorated by silicon application in vegetables. *International Journal of Phytoremediation*.24 (14):1543-56.
- Nlend B, Celle-Jeanton H, Huneau F, Ketchemen-Tandia B, Fantong WY, Boum-Nkot SN, Etame J.2018. The impact of urban development on aquifers in large coastal cities of West Africa: Present status and future challenges. *Land Use Policy*. 75 :352-63.
- Onounga DD, Etsiba S, Sah MR. 2023. Industrialisation et changement climatique en République du Congo. *Revue Française d’Economie et de Gestion*.4 (5).
- OMS, 2021. Organisation Mondiale de la Santé. Directives de la qualité de l’eau de boisson, 3rd édition. Genève. P 595
- Samantha F, David CB, Maureen LC, Pushpam K, Agnes B, Juliette BK, Yongjoon P, Gabriella T, Philip JL. 2021. Air Pollution and Development in Africa : Impacts on Health, the Economy and Human Capital. United Nations Environment Programme.
- Santsa CVN, Ndjouenkeu R, Ngassoum MB. 2022. Eau du bassin versant de la Menoua (Cameroun) et pollution agricole: risque chimique inhérent à sa consommation. *Environnement, Risques & Santé*.21(2) :157-68.
- Schraufnagel DE, Balmes JR, Cowl CT, De Matteis S, Jung SH, Mortimer K, Perez-Padila R, Rice MB, Riojas-rodriguez H, Sood A, Thurston GD. 2019. Air Pollution and Noncommunicable Diseases: A Review by the Forum of International Respiratory Societies’ Environmental Committee, Part 1: The Damaging Effects of Air Pollution. *Chest*.155 (2):409-16.
- Silva DB da, Pianovski MAD, Carvalho Filho NP.2024. Environmental pollution and cancer. *Journal de Pediatria*.
- Soumbougma A, Kadeba A, Compaore NF. 2020. Caractérisation des effluents industriels et effets de leur utilisation agricole sur la santé des populations: cas de la commune de bobo-dioulasso. *Revue Ivoirienne des Sciences et Technologie*.36 (2020) 52-68
- Tatou RD, Kabeyene VK, Mboudou GE. 2017. Analyse multivariée pour l’évaluation de l’hydrogéochimie des eaux souterraines dans le bassin versant supérieur de Kambo (Douala, Cameroun). *Journal of Geoscience and Environment Protection*. 5(3)
- Vardhan KH, Kumar PS, Panda RC. 2019. A review on heavy metal pollution, toxicity and remedial measures: Current trends and future perspectives. *Journal of Molecular Liquids*. 290:111197.
- WHO. 2017. World Health Organization, Guidelines for drinking water quality. Fourth edition incorporating the first addendum. 1-631
- Zaynab M, Al-Yahyai R, Ameen A, Sharif Y, Ali L, Fatima M, Khan K, Li S. 2022. Health and environmental effects of heavy metals. *Journal of King Saud University - Science*. 34(1):101653.